AFRL-HE-WP-TP-2006-0009

AIR FORCE RESEARCH LABORATORY

Advanced UMV Operator Interfaces

Jeremy Nelson

Human Effectiveness Directorate
Warfighter Interface Division
Wright-Patterson AFB OH 45433

January 2006

Human Effectiveness Directorate
Warfighter Interface Division
Wright-Patterson AFB OH 45433

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)* January 2006	**2. REPORT TYPE** Technical Report Chapter	**3. DATES COVERED** *(From - To)*
4. TITLE AND SUBTITLE Advanced UMV Operator Interfaces		**5a. CONTRACT NUMBER** **5b. GRANT NUMBER** **5c. PROGRAM ELEMENT NUMBER**
6. AUTHOR(S) Jeremy Nelson		**5d. PROJECT NUMBER** 7184 **5e. TASK NUMBER** 09 **5f. WORK UNIT NUMBER** 72
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)		**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Materiel Command Air Force Research Laboratory Human Effectiveness Directorate Warfighter Interface Division Wright-Patterson AFB OH 45433-7022		**10. SPONSOR/MONITOR'S ACRONYM(S)** AFRL/HECI **11. SPONSOR/MONITOR'S REPORT NUMBER(S)** AFRL-HE-WP-TP-2006-0009

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
This is a chapter that will be published in a NATO-RTO technical report. The clearance number is AFRL/WS-06-0153 cleared 19 January 2006.

14. ABSTRACT
This chapter compares various platforms for advanced UMV operator interfaces. The platforms discussed are: Man-portable platform; Restricted-space platforms; Large-space platforms.

15. SUBJECT TERMS
UMV operator interface, platforms

16. SECURITY CLASSIFICATION OF: Unclassified			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Jeremy Nelson
a. REPORT UNC	**b. ABSTRACT** UNC	**c. THIS PAGE** UNC	SAR	7	**19b. TELEPHONE NUMBER** *(include area code)* (937) 255-6943

6.6.1 Scale of UMV Operator Interface

Scale, for purposes of this discussion, is used to describe the constraints imposed upon the design of UMV control stations. The scale ranges from man portable to large space platforms and all are limited to single operator control.

6.6.1.1 Man-portable Platforms

In man portable platforms, the UMV is ideally very small, lightweight, rugged, and easy to operate [1]. It is essential that this platform meet these characteristics because a typical operator will be transporting the entire UMV system along with other mission critical equipment. These UMVs are usually used for "what's over the hill" type missions; requiring fairly autonomous operation to gain time critical, nearby information. The control stations for man portable UMVs will typically be no larger than a laptop and can be made to fit on smaller devices such as a PDA or head-mounted displays. For example, the Pointer UAV, developed by AeroVironment Corporation, is operated by the user through a large tablet-like PDA [2] (Figure 1). Another example of this can be seen in the work of Goodrich and Quigley (2004) [3]. However, ruggedization of this equipment will generally increase weight and size.

Figure 1. Man-portable control station. Source: http://www.aerovironment.com/

6.6.1.1.1 Affordances Provided by Man-portable Platforms

Of the three main classes of UMV control stations, man portable stations afford the fewest resources for interfacing with the vehicle. Often times man portable UMVs require direct line-of-sight control of the vehicle. This allows more immediate responses to control inputs. The short duration of operations and lack of control station equipment should minimize the amount of ergonomic concerns with respect to body posture, workstation design, etc. Decreased available interface real estate requires simplified control inputs into the UMV system, and varied operating environments may allow for more unconventional input methods into the system such as speech recognition.

6.6.1.1.2 Constraints Associated with Man-portable Platforms

Interface designs must be optimized for essential basic functions, leaving little room for displays and controls that may expand capability. Further, the operating environment of a man portable UMV control station can vary more than restricted space and unlimited space platforms, increasing the need to make robust, hardy equipment. Control input devices cannot be overly sensitive or delicate (e.g., a PDA-style stylus may be too fragile of an input device if the operating environment requires all weather operations). Display screens must be able to be viewed under less-than-ideal conditions (e.g., bright desert environments), and access to C^2 information for these systems is limited. Operators must act as the vehicle director and perform multiple other functions that need to be executed, requiring a large amount of autonomy on the vehicle's part. Man portable UMV platforms create many challenges if an operator needs to operate more than one vehicle at a time.

6.6.1.2 Restricted-space Platforms

Restricted space control stations are characteristically built to be semi-mobile, often in a portable trailer. However, restricted-space platforms may also be in the back of another vehicle, such as a

HMMWV or tight quarters on a ship. Space is often limited, varying based on the UMV system it supports, but there is no requirement for the system to be man portable. An example of a restricted space control station can be seen in Figure 2.

6.6.1.2.1 Affordances Provided by Restricted-space Platforms

UMV restricted space control stations possess much more interface space compared to man portable systems. Additionally, the UMV control station operating environment can be managed to a large degree with respect to the station's temperature, lighting, noise, etc. This allows some degree of flexibility in the design of the displays and controls, as they do not have to be as hardy. The increased space in these stations also allows operators to have additional, but not necessarily vital tools, to improve areas such as situational awareness and workload. However, it is important to remember that display and information input space, while larger the man portable systems, can quickly become congested. Another benefit to the restricted space control station is the greatly improved access to C^2 information as these platforms have the potential for SATCOM communications.

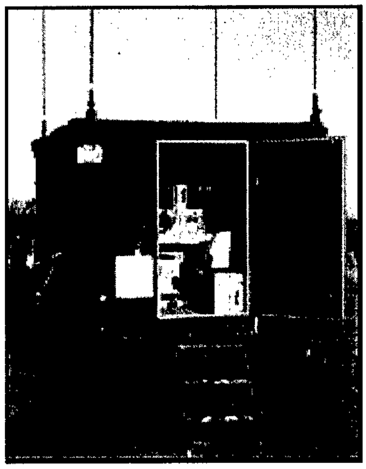

Figure 2. Restricted-space platform. Source: http://www.airforce-technology.com/

6.6.1.2.2 Constraints Associated with Restricted-space Platforms

As would be expected, restricted space platforms have fewer constraints than man portable stations, but more than unlimited space designs. Often, achieving a good ergonomic layout in restricted space control stations is difficult. Vehicles operating from these control stations usually demand high levels of operator oversight, requiring multiple display and control surfaces. Fitting all the controls and displays is typically the first priority; accommodating the human is secondary. Maintenance access is often restricted as is any redundancy in the controls or displays. Information input is often performed through the use of conventional mouse, keyboard, and/or joystick devices. Technologies such as speech recognition can ease the space requirements for control surfaces in these platforms and allow for more display area, better ergonomics, and increased capability tools. Human interface design needs to consider how best to access and display large amounts of information on few displays (i.e., what is an appropriate cognitive distance for each item, how much digging for information should be required –information depth versus breadth, etc.).

6.6.1.3 Large-space platforms

In a platform where space is abundant and more than able to accommodate (see Figure 3), the station would most likely be located in some sort of bunker or building [1]. These arrangements allow for the greatest degree of control with respect to the control station operating environment (e.g., temperature, lighting, noise, etc.), but the least amount of mobility. These systems might typically be large platforms with highly autonomous vehicles performing numerous functions that are all tied in to netcentric feeds. Some examples of large-space platforms can be seen in research with data walls.

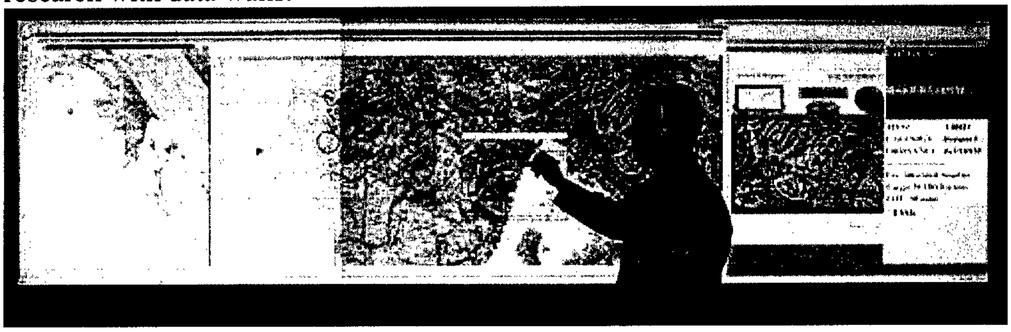

Figure 3. Large-space platform example – a data wall at AFRL. Source: http://www.rl.af.mil/

6.6.1.3.1 Affordances Provided by Large-space Platforms

Perhaps the most appealing aspect of a large space platform is that it could allow for a truly user-centered design approach as defined by Norman and Draper (1986) [4]. While the user-centered design approach should be used for the man portable, restricted space, and large space platforms, it can more fully be exploited in the large space system. Using this approach, the system could be designed with the user in mind at all stages, maximizing the technologies that would allow an operator to function at peak efficiency and effectiveness. It is possible to incorporate all expanded capabilities as well as basic functionality. The size could be enlarged to fully accommodate proper ergonomic design, information input, and display space needs of a human operator. In the large space platform, it is possible to completely control the operator's working environment – ensuring no stray lights, sounds, or other disturbances interfere. This type of platform would be ideal for controlling multiple UMVs or any type of system that requires crews of operators.

6.6.1.3.2 Constraints Associated with Large-space Platforms

The unlimited space design is not without constraints. The biggest drawback is its lack of mobility. To move the entire station from one area to another becomes a long and arduous task. There is also an issue of oversaturation. For instance, just because there may be space to add an additional monitor to the workstation does not mean it would improve the operator's performance. Providing an operator with additional channels of information to monitor can decrease overall situational awareness, increase workload, increase the possibility of errors due to missed information or misperceived information, increase the possibility of cognitive tunnelling, as well as a host of other problems. Human factors engineering would need to ensure the system does not inundate the user with too much information or too many controls.

6.6.1.4 References for Scale of UMV Operator Interface

[1] U.S. Department of Defense. Unmanned Aircraft Systems Roadmap 2005. Retrieved November 30, 2005, from http://www.acq.osd.mil/usd/Roadmap%20Final2.pdf

[2] AeroVironment, Inc. Pointer FQM-151A: Unmanned Aerial Vehicle (UAV) System. Retrieved November 3, 2005, from http://www.aerovironment.com/area-aircraft/prod-serv/ptrdes.pdf

[3] Goodrich, M. & Quigley, M. (2004). Mini-UAV telemetry and imaging visualization for searching tasks [Abstract]. *Proceedings of the Cognitive Engineering Research Institute Annual Human Factors of UAVs Workshop, 1.* Retrieved December 1, 2005, from http://www.cerici.org/workshop/abstract/Goodrich.pdf

[4] Norman, D. A., & Draper, S.W. (Eds.). (1986). *User centered system design.* Hillsdale, NJ: Lawrence Erlbaum Associates.

6.6.2 UMV Operation from Moving Platforms

An interesting and even more complex problem arises when considering the control of UMVs from moving platforms. One possibility of this is a man portable system being controlled as the operator is on the run. The operator, now the moving control platform, must operate a UMV while actively maneuvering his/her own body. However, the typical scenario is envisioned as a UMV operator controlling the UMV from a station located in a moving vehicle. Operators must maintain spatial orientation and awareness of the UMV, while simultaneously sensing and understanding the dynamics of their own vehicle [1].

The lack of proprioceptive feedback inherent with UMVs can increase the workload for operators trying to maintain spatial orientation and awareness. Sensory information afforded an operator is drastically reduced and delivered almost entirely through the visual channel. Operators controlling UMVs from moving platforms receive sensation cues completely independent from the vehicle being remotely controlled. This problem is compounded by the fact that the operating environments of the vehicles may be different and could change during the duration of the operator's control of the UMV. For example, an operator controlling a UAV must maintain spatial orientation and awareness of the UAV, while possibly operating from an air, ground, sea, or underwater vehicle. The proprioceptive cues of the ground, sea, or underwater environments can vary greatly from those of the aerial environment and would compound the mismatch of cues, increasing the difficulty of controlling a UMV and potentially leading to motion sickness (described in greater detail below).

In the above scenarios, the operator is simply operating the UMV while another operator controls the platform containing the UMV control station. However, it is also plausible that a single operator will directly control a vehicle while also attempting to control one or more UMVs. This presents some unique challenges [1]. While it may reduce manpower and equipment needs, it may also require some control devices and display surfaces to act as inputs and displays for both the manned and unmanned vehicles. Issues emerge as to how best to switch the control and display between the vehicles, and which input devices and display surfaces can be used for both vehicles and which should be solely dedicated. This becomes an issue of supervisory control – to what degree does the operator need direct control and what areas of operation should be made autonomous?

Regardless of who is controlling the operator's vehicle, certain key concerns have been identified by McCauley and Matsangas (2004) [2] that must be addressed for UMV operations from a moving platform:

- How should spatial information about own-vehicle and controlled vehicle(s) be displayed to the UMV operator?
- Can individual differences in spatial orientation and mental rotation be used as criteria for selecting and assigning UMV operators?
- What types of training and simulation systems are necessary to develop the necessary skills to manage complex multivehicle dynamics?

In addition to the challenges of navigation/spatial orientation, other issues of concern are motion sickness, biodynamic interference with manual control, and head-mounted display (HMD) bounce. Motion sickness can occur when the visual cues of motion differ from those perceived by the inner ear, creating a sensory conflict [3]. Motion sickness can include nausea, dizziness, disorientation, and increased stomach awareness. Another issue is that of biodynamic interference, or, the input to manual control devices from the shock and vibration of rough terrain, transmitted from the vehicle to the operator and into the controls. This is especially common in UGV operations. And finally, HMD bounce refers phenomena of HMDs resonating at certain frequencies of vertical axis vibration, which are often found in ground vehicles [4]. The HMDs "bounce" relative to the face and eyes of an operator, degrading visual performance.

6.6.2.1 References for UMV Operation from Moving Platforms

[1] Walter, B.E., Knutzon, J.S., Sannier, A. V., & Oliver, J.H. (2004). Virtual UAV Ground Control Station. *Proceedings of the American Institute of Aeronautics and Astronautics: 3rd "Unmanned Unlimited" Technical Conference, Workshop and Exhibit.* AIAA 2004-6320.

[2] McCauley, M. E., & Matsangas, P. (2004). "Human Systems Integration and Automation Issue in Small Unmanned Aerial Vehicles." Naval Postgraduate School.

[3] Reason, J., and Brand, J. J. (1975). *Motion Sickness*. London: Academic Press.

[4] Sharkey, T.J., McCauley, M.E., Schwirzke, M.F.J., Casper, P., & Hennessy, R.T. (1995). The Effects of Whole Body Motion, Head Mounted Display, and Hand Control Device on Tracking Performance. Warren, MI: U.S. Army Tank and Automotive Command.